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SILASTENE COATING FOR POLLUTION REDUCTION IN A HOT-SHOT WIND TUNNEL. INSPECTION BY SPECTROSCOPY

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SILASTENE COATING FOR POLLUTION REDUCTION IN A HOT-SHOT WING TUNNEL. INSPECTION BY SPECTROSCOPY

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ABSTRACT. A silastene coating applied to the walls of the ARC II wind tunnel is described. It increases the lift time of the wind tunnel by five times.

The optical and radio-electrical phenomena connected with the re-entry /51* of bodies into the atmosphere requires a rather complete simulation of flight conditions in order to study them in the laboratory.

Electrical arc (hot-shot) wind tunnels satisfy this requirement in terms of velocity, volume mass flow and allowable scale of the models, but the means previously used [1] in order to assure the clearness of the flow become ineffective at the temperature level ($\geqslant$ 5,000 °K) required for this type of instrument.

Metallic pollutants, which can have an influence on the ionization rate of the gas which is difficult to analyze, stem primarily from the arc chamber which feeds the wind tunnel.

A consummable protecting coating (silastene) has been applied to the hot-shot ARC II O.N.E.R.A. wind tunnel located at Fontenay-aux-Roses. The effectiveness of this coating was controlled by a spectrographic method.

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* Number is the margin indicate the pagination in the original foreign text.

The spectrographic analysis of the plasma which forms around a model makes it possible to find the nature of the pollutants of a high Mach number flow. These pollutants are in the molecular stage or in the form of solid particles.

Figure 1 shows the parts used in the experiment:

R = 50 mm

d = 6 mm approximately

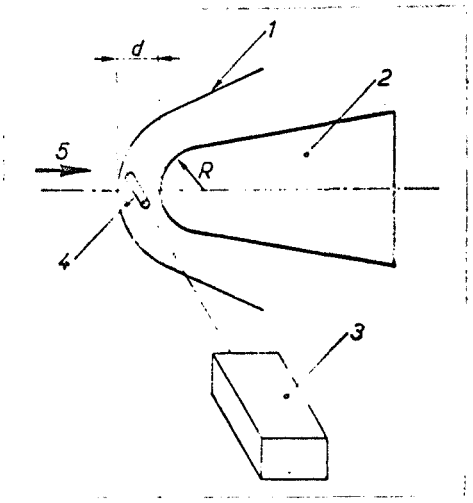

Figure 1. Arrangement of the parts of the experiment.

1. shock wave; 2. model; 3. spectrograph; 4. volume v studied; 5. direction of the flow.

The volume "v" studied is a cylinder 0.6 mm in diameter having an axis perpendicular to the direction of the flow.

The emission spectrum of the volume v of gas, shown in Figure 2, was obtained for the following conditions:

-- gas used: nitrogen
-- spectral region, $3\,500\ \text{Å} < \lambda < 7\,000\ \text{Å}$,
-- resolution 5Å on Kodak 2475 film,
-- continuous exposure of the film during the flow /52
-- temperature of the nitrogen contained in the arc chamber: from 7000 to 8000°K,
-- no protective coating along the wall of the arc chamber.

Identification of the lines obtained shows the presence of the following principal emitting particles:

Cu I, Fe I, Al I, Cr I, Ca I, Na I.

These impurities stem from the high voltage electrode made of cuprotungsten and from the steel and copper wall of the chamber, which plays the role of an electrode at zero potential.

Examination of the chamber after a high temperature run seems to indicate that the pollutants contained in the flow stem primarily from the wall. The thermal loss affect is not sufficient to avoid its fusion.

The presence of these impurities has the following primary consequences:

1. The nature of the elements emitted is changed due to chemical reactions between molecules, ionized atoms and non-ionized atoms;
2. The quantity of free electrons after passage through the shock wave around the model is changed;
3. The thermal losses in ther arc chamber are increased;
4. The arc chamber is more rapidly destroyed.

The emission lines or bands of the impurities, which are superimposed on the lines of the gas to be studied, make it difficult to study the latter. It should be noted that metals, and primarily iron, which are easy to ionize have a large number of lines in the explored spectral region and have an increased emissive capacity.

It should also be noted that the free electrons stemming from metallic molecules can obstruct the observation of the vibration-rotation bands such as the one of a nitrogen molecule ionized once, due to recombination ahead of the shock wave with the ions of the gas to be studied.

By using a thin layer of silastene deposited on the wall of the chamber before each experiment, it is possible to practically suppress the metallic

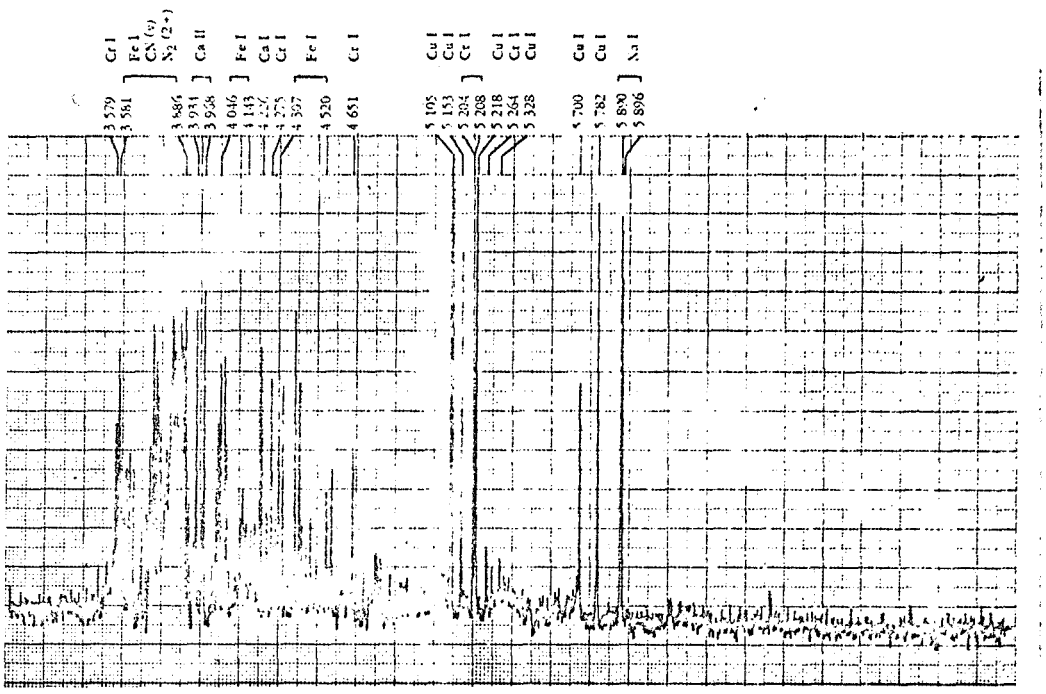

Figure 2. Emission spectral run No. 339.
T = 700°K approximately. Wall of the arc chamber without coating.

pollutants as shown in Figure 3. For this experiment, the temperature was of the same order as in the previous case.

The lines recorded are those of cyanogene CN (v), and the carbon which is contained is due to the decomposition of the silastene.

Even though one does not observe an emission band corresponding to the once ionized nitrogen N_2^+ around 3900 Å, it is possible for the second positive system of the non-ionized nitrogen N_2 (2_i+) to be present. The latter partially cover the bands of the CN and follow each other up to about 2900 Å. However, the film used is not sensitive beyond 3500 Å. The cyanogene is a part of the pollutants, but due to the fact that in the emission region of CN(v)

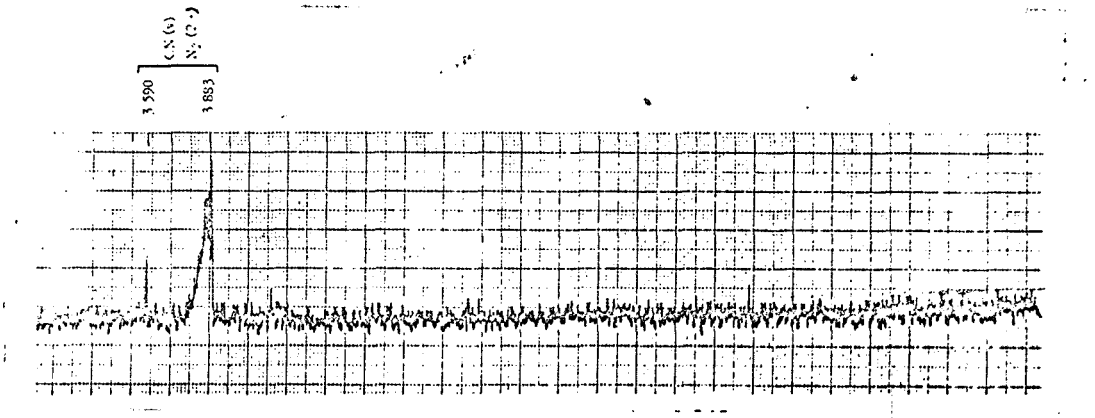

Figure 3. Emission spectral run No. 365.
T = 8000°K approximately. Wall of the arc chamber coated with silastene.

the intensity of $N_2(2+)$ is weak, it is still possible to use it as a means of measuring the temperature of the gas to studied.

It is known that the CN molecule is a good thermometer for temperatures below 9000°K [2, 3].

Considered as a protective material, the silastene makes it possible to eliminate undesirable metallic pollutants and to introduce an interesting tracing element. It should also be pointed out that it also introduces the gas flow (Co, SiO, H_2) which is not desirable. In any case, the amount of silastene which decomposes during an experiment is limited to a few grams and only introduces a small porportion of these gases. Their effect can be taken into account in non-equillibrium flow calculation programs In addition to producing a pure flow, the coating also has the advantage of reducing by about 50% the thermal losses at the walls and of increasing the lifetime of the arc chamber by five times.

This protection method was used regularly in the ARC II wind tunnel after January 1969.

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